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# **EXECUTIVE SUMMARY**

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## **PROJECT PURPOSE**

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This study was prepared for the State Department of Business, Economic Development and Tourism (DBEDT) as part of the Hawaii Energy Strategy program. Authority and responsibility for energy planning activities, such as the Hawaii Energy Strategy, rests with the State Energy Resources Coordinator, who is the Director of DBEDT.

Hawaii Energy Strategy Study No. 5, Transportation Energy Strategy Development, was prepared to:

- collect and synthesize information on the present and future use of energy in Hawaii's transportation sector;
- examine the potential of energy conservation to affect future energy demand;
- analyze the possibility of satisfying a portion of the state's future transportation energy demand through alternative fuels; and
- recommend a program targeting energy use in the state's transportation sector to help achieve state goals.

The analyses and conclusions of this report should be assessed in relation to the other Hawaii Energy Strategy Studies in developing a comprehensive state energy program.

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## **CURRENT AND FUTURE ENERGY USE IN THE TRANSPORTATION SECTOR**

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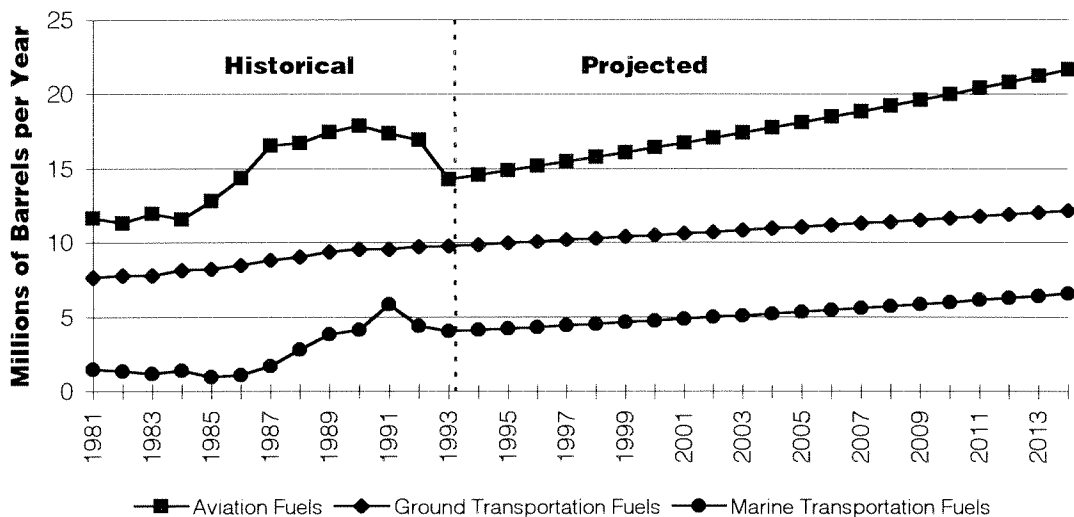
Chapter 2 profiles recent energy use in the state's ground, air and marine transportation sectors. The amount of fuel consumed by all sectors combined increased from about 20.7 million barrels in 1981 to about 31.5 million barrels in 1990, a compounded annual rate of increase over that period of approximately 4.29 percent. Since 1990, however, energy use

has decreased in the aviation sector and grown only slowly in the ground sector. Total annual consumption in 1992 was 31.0 million barrels, a 0.8 percent decrease from 1990.

In 1992, Hawaii 's transportation sector consumed 62 percent of the petroleum and 55 percent of the total energy used in the state. Of the three transportation sectors, air transportation consistently consumes the most energy by a substantial margin, representing over 50 percent of the transportation sector's total energy demand.

Based on existing transportation plans, energy use in the state's transportation sector is projected to increase at an annual average rate of 1.75 percent between 1993 and 2014, increasing the state's already large dependence on imported oil. Historical and projected transportation fuel use are shown in Figure 1. This projection serves as the basis to examine the potential for energy conservation and petroleum displacement by alternative fuels.

**Figure 1.**  
**Transportation Fuel Sales Volumes by End Use, 1981-2014**



The state has little opportunity to affect energy usage in the air and marine sectors, but could potentially have a significant influence on energy usage in the ground sector. With the ground sector representing 20 percent of the petroleum consumed in the state in 1992, and with ground sector energy demand projected to increase at a 1.05 percent annual rate between 1993 and 2014, the ground sector represents a sufficiently large component of the state's total energy demand to be worthy of attention.

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## **THE POTENTIAL OF CONSERVATION**

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Chapter 3 focuses on the effectiveness of energy conservation measures applicable to the ground transportation sector. Measures that improve the average efficiency of vehicles used in the state (miles per gallon) would have a powerful effect on energy demand, and large enough increases in efficiency would reduce energy demand without altering travel behavior, lifestyle or land use development patterns.

In addition, the amount of energy “wasted” due to roadway congestion is appreciable. Estimates based on transportation modeling approaches indicate that ground sector fuel demand could be reduced by around ten percent if measures to eliminate congestion were implemented.

Changes in travel behavior and land use development patterns could also reduce future energy demands below projected levels. Chapter 3 describes 28 transportation system management measures, including changes in land use development patterns, and concludes that the transportation system management measures with the greatest potential for reducing transportation energy demand are:

- expansion of public transit;
- high occupancy vehicle (HOV) facilities;
- automobile use limitations;
- transportation management associations;
- actions by educational institutions; and
- energy-efficient land use patterns.

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## **PETROLEUM DISPLACEMENT**

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Even with conservation measures, petroleum demand is projected to continue to increase. The displacement of a significant portion of petroleum use in the ground transportation sector by locally-produced alternative fuels could, with a properly designed implementation program, help reduce demand for petroleum-based fuels and thereby achieve both energy security and economic stimulus goals.

Because of the benefits of petroleum substitution, the relatively higher price of petroleum products in Hawaii compared to the mainland, the availability of waste and renewable resources with the potential for production of alcohol and electricity, an agricultural infrastructure capable of conversion to energy crops, and climate and geography which provide a good match with the characteristics of EVs, Hawaii has a foundation at least as strong as any other state on which to begin a program to achieve substantial petroleum displacement in the ground transportation sector.

An aggressive program involving mandates and subsidies could displace 22 percent of the petroleum used in the state's ground transportation sector by 2014. This level of displacement is consistent with national goals. More aggressive petroleum substitution would be limited by the rate at which vehicles capable of using alternative fuels could be introduced, and the time required to establish alternative fuel production and distribution systems. Less aggressive substitution would defer the benefits of substitution.

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## **CANDIDATE ALTERNATIVE FUELS**

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Chapter 4 introduces the alternative fuels most frequently proposed to replace gasoline and diesel in the ground transportation sector, reviews government efforts to support alternative fuels, and presents possible Hawaii-specific scenarios for substituting petroleum with alternative fuels. This study addresses the following alternative fuels: alcohols (methanol and ethanol), natural gas, propane, electricity, biodiesels and hydrogen. Technologies to utilize alternative fuels is either well-developed or developing rapidly, and Hawaii has had previous and ongoing experience with most of them.

The National Energy Policy Act of 1992 (EPACT) requires the use of alternative fuels in steadily increasing numbers of light duty vehicles, beginning with federal fleet vehicles in 1994, state and fuel provider fleet vehicles in 1996, and private and municipal fleets as early as 1999.

It may not be appropriate to pursue all of the alternative fuels, however. In Chapter 5, the fuels are screened in relation to their potential contribution to a set of strategic and near-term considerations.

The analysis in Chapter 5 concludes that electric energy and alcohol have the potential to provide more benefits than the other alternative fuels. While propane has and is expected to gain increasing market share through public and private sector efforts, it is tightly linked to the petroleum market and therefore does not satisfy the energy security criterion as well as alcohol and electricity. Biodiesel satisfies the strategic criteria, but encounters a large price penalty. Hydrogen powered vehicles have been built, but they are not expected to be commercially available soon. Natural gas fails to meet the criteria listed above because, among other shortcomings, it is not available in Hawaii and the only locally available gas is

synthetic natural gas, which has not been proven as a usable fuel with commercially-available internal combustion engines.

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## **INFRASTRUCTURE REQUIREMENTS**

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Chapter 6 describes the existing gasoline and diesel distribution infrastructure and some of the implications on fuel distribution infrastructure that would be associated with implementing alternative fuels programs.

Storing, distributing and marketing biodiesel and propane for use in motor vehicles in Hawaii would be relatively uncomplicated. Biodiesel blends can use the existing diesel distribution infrastructure, provided the seals and other components which are made of rubber are compatible with biodiesels. The necessary propane infrastructure already exists and can be expanded as needed.

Low-level alcohol blends can use the existing gasoline retail structure as they do in other states where fuel blending is common. Infrastructure for neat alcohols and high-level alcohol blends is not in place, and use of such fuels would require properly engineered bulk storage facilities and refueling station systems, as well as appropriate methods of truck and barge transfer of the alcohol fuel.

Electric vehicle (EV) infrastructure is in place in the sense that electric utilities serve the islands and most people have electric service. Additional EV-related infrastructure would include charging stations at residences, public locations, and businesses, and battery recycling and disposal facilities. Utilities would need to assess the impact of increasing numbers of EVs on their systems; while off-peak charging of EVs could provide operational benefits to utilities and therefore should be encouraged, on-peak charging should be avoided.

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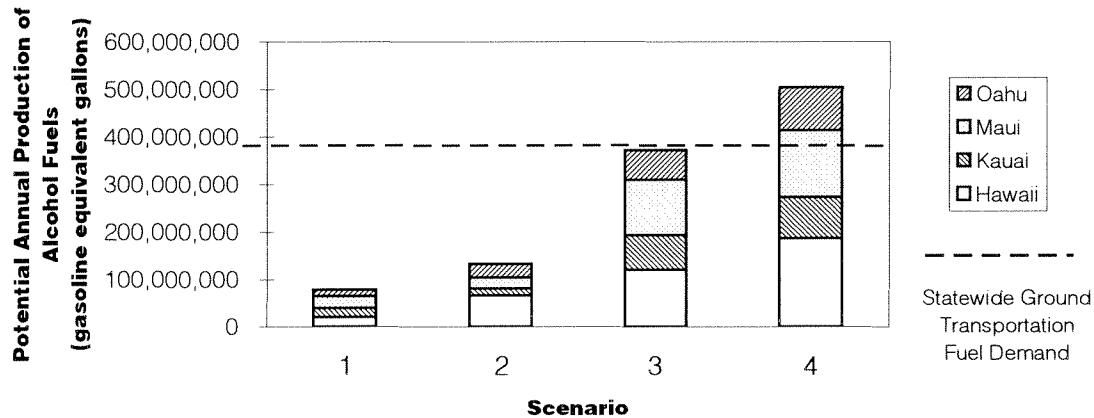
## **POTENTIAL FOR LOCAL PRODUCTION OF ALTERNATIVE FUELS**

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The potential for local production of alternative fuels is presented in Chapter 7. Several scenarios for large-scale energy crops and alternative ground transportation fuel production were considered, including: 1) use of agricultural byproducts and organic wastes; 2) use of only those lands (or equivalent lands) taken out of intensive cultivation during the past 25 years (approximately 100,000 acres); 3) conversion of all lands presently in intensive cultivation (nearly 230,000 acres) to energy crop production; and 4) use of those lands (or

equivalent lands) presently and previously (25 years ago) in intensive agriculture (nearly 330,000 acres). Selected results of these scenarios are shown in Figure 2.

**Figure 2.**  
**Potential Transportation Energy Production in Hawaii from Energy Crops, Agriculture Residues, and Wastes**



## **COSTS**

Chapter 8 presents an analysis of the costs that would be associated with alternative fuel use in the ground transportation sector. Costs span a wide range depending on the particular alternative fuel, the feedstock, the scale of production, the nature and pace of technological improvements, whether the fuel would be produced locally or imported, and if locally produced, whether fuel production would occur on the same island as fuel use. Cost projections in this chapter are retail, "at the pump" amounts which include infrastructure, shipping cost, and tax components. Overall, given current technology, prices and taxes, alternative fuels, other than low-level ethanol blends, are more costly than gasoline. (It should be noted, however, that gasoline and diesel are themselves subsidized fuels.)

Long-range, large volume alcohol production scenarios suggest that high-level alcohol blends (M85 and E85) could provide energy at costs only slightly higher than current prices for gasoline and diesel, although near-term, low volume scenarios show that alcohol costs could be substantially higher than present gasoline and diesel prices. The projected costs of biomass-derived alcohols are primarily influenced by feedstock price, processing cost, plant scale, and, in scenarios which include barging between islands, shipping and terminal-related costs.

Fuel taxes are another important element in projected fuel costs at the pump. Under current State and County fuel tax laws, motor fuels are taxed on a per-gallon basis. This puts most alternative fuels at a disadvantage on a cost-per-mile basis, since alternative fuel vehicles use more gallons to travel the same distance. Revising fuel taxes to be based on energy content

would remove a disincentive to the use of alternative fuels while preserving current levels of tax revenue.

For some applications, propane is competitive with gasoline now. For fleet use of propane, the main cost element is the vehicle conversion cost. For non-fleet use of propane, the high price of retail propane is one inhibiting factor.

For electric vehicles, the most significant cost element is the cost of the vehicles. A variety of technologies, manufacturers and prices are currently available, but the rapid pace of development in this area makes a comparative cost estimation for EVs difficult. If EV purchase costs could be reduced, EVs could become very cost-competitive in the marketplace.

If the benefits of alternative fuels can be shown to justify the costs of an alternative fuel program, government action may be warranted. Chapter 9 examines measures the state could take, ranging from the least intrusive (the support of research and development) to the most intrusive (government provision of fuel). Some of the measures require the state to commit to a particular fuel type and alternative energy program, while other measures, such as adjustment of fuel taxes to reflect the lower energy content of alternative fuels, reduce existing barriers without promoting any particular fuel.

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## **IMPACT AND EFFECTIVENESS OF POTENTIAL ALTERNATIVE FUEL PROGRAMS**

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In Chapter 10, potential measures to increase the use of alternative fuels are evaluated in terms of achieving long-term objectives of energy security, environmental sustainability and local economic stimulus. Measures to encourage the use of alternative fuels are generally intended to reduce or eliminate barriers to alternative fuel vehicle (AFV) adoption, such as the lack of infrastructure, fuel availability and cost, and consumer acceptance. Actual benefits and costs are difficult to quantify and have many uncertainties.

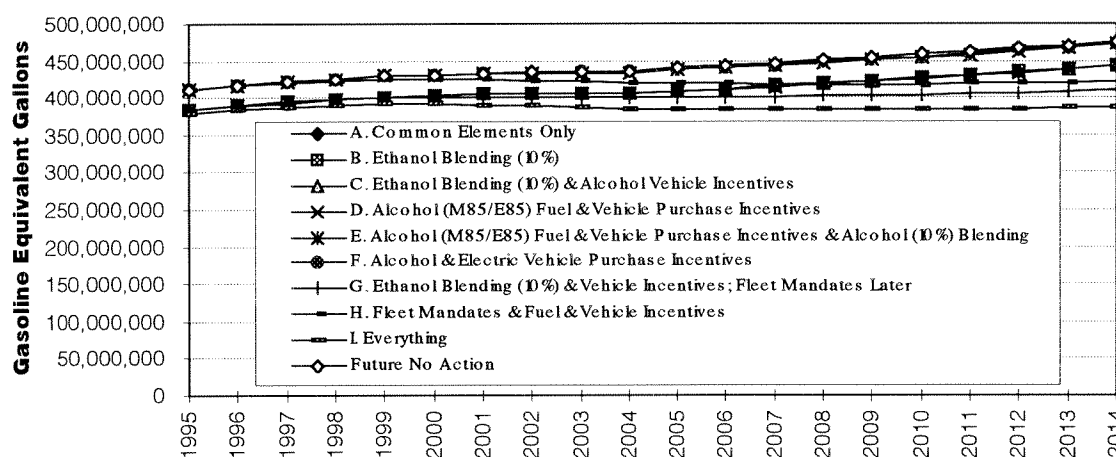
The development of a local alternative fuels program could have beneficial economic effects such as the preservation and creation of jobs in agriculture and in electric vehicle (EV) support and manufacture. A local alternative fuel industry would also retain within the state a larger portion of its substantial energy expenditures. Such a program could also have a secondary effect of enhancing the state's tourist appeal through maintenance of a thriving agricultural economy, thus reinforcing Hawaii's appeal as a clean and healthy destination. In addition, reduced shipping of crude oil into the state reduces the possibility of oil spills.

Transition to widespread use of alternative fuels is a gradual process, primarily due to the time necessary to introduce AFVs into the vehicle population. Near-term actions to foster the production and use of alternative fuels are necessary first steps to achieve long-term goals.

Certain potential measures to encourage the use of alternative fuels have already occurred to some extent, are occurring or are expected to occur voluntarily, or are essentially non-controversial and non-cost items. These include: provisions that new or replacement fueling facilities be alcohol compatible; the availability of off-peak charging for EVs at reduced rates; the adjustment of fuel tax rates on the basis of energy content; certain requirements that fleets purchase AFVs; and public education and outreach programs.

Measures and groups of measures (scenarios) were evaluated on the basis of effectiveness and cost. Scenarios were developed which included such measures as ethanol blending, alcohol or electric vehicle purchase incentives, and mandates that fleets purchase AFVs. The effectiveness of each scenario was estimated in terms of the amount and cost of gasoline and diesel displaced, the number of alternative fuel vehicles in use, and the scenario's employment potential. Projected gasoline and diesel demand under various scenarios is shown in Figure 3.

**Figure 3.**  
**Projected Gasoline and Diesel Demand Under Various Scenarios, 1995-2014**



## RECOMMENDATIONS

Although aviation is the dominant sector with respect to fuel use, this report concludes that the ground transportation sector is the sector most amenable to impact by state and local actions. Chapter 11 presents an action plan to influence energy use in the ground transportation sector. Experience on the mainland and elsewhere has shown the need for successful programs to be integrated, publicly-supported packages of requirements, incentives, research, outreach and public information, governmental actions and monitoring programs. Because of these interrelationships, it is appropriate to integrate all elements relating to ground sector energy use into a package addressing conservation, alternative fuel supply and demand, and alternative fuel vehicle (AFV) supply and demand. The plans must be evaluated for personnel and resource requirements.



Analyses presented in Chapter 10 show that an alcohol gasoline blend program is the most cost-effective means of encouraging the use of significant quantities of renewable, locally produced alternative fuels. As discussed in Chapter 10, projected costs may be justifiable since jobs would be preserved and created immediately as energy crop production commenced.

Reducing the cost of off-peak recharging of electric vehicles, adjusting fuel taxes to be based on energy content, and public education programs are recommended low-cost and low-risk components of a near-term program.

It is also recommended that state transportation energy efforts focus on energy conservation and to a lesser degree, congestion relief. The goal of energy conservation efforts would be to increase the average fuel efficiency of motor vehicles in the state and change travel behavior and land use patterns. Improving and expanding public transportation and other methods of decreasing vehicle miles traveled would have immediate energy savings, while transportation and land use planning would have the greatest projected long-term energy conservation potential.

Research and development programs would also play an important part in the achievement of Hawaii's energy goals. It is recommended that in the near-term the state research such areas as fleet purchase requirements and effectiveness in other states, methods to reduce the number of vehicle miles traveled, and programs to increase fuel efficiency.

The near-term program would last approximately seven years. By that time it is estimated that approximately 10,000 alternative fuel vehicles would be in use in Hawaii.

At the beginning of the mid-term program, it would be appropriate to reevaluate the cost, availability and desirability of the various alternative fuel vehicles and incentives. Fleet incentives and mandates may also be part of the mid-term program.

In the mature program, alternative fuels would have achieved cost-effective scales of production and distribution, and government subsidies and incentives would be phased out.

In developing a comprehensive state energy program, the ground transportation sector is an area where significant energy savings and petroleum substitution can be achieved. A balanced approach incorporating conservation, alternative fuel measures, research and development, outreach and monitoring is recommended. Conservation measures, which would reduce the number of vehicle miles traveled and reduce congestion, could be a central part of state policy. Reduced off-peak recharging rates for EVs, fuel taxes based on energy content and public education programs are essential to the continued and expanded use of alternative fuels and vehicles. Alcohol blending, fleet purchase mandates and vehicle purchase incentives could also be implemented. Research and monitoring of ground sector transportation issues need to continue and the public must be educated and informed of the options and policies affecting transportation in the state.